TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. 15, No. 1, July 2015, pp. 191 ~ 196
DOI: 10.11591/telkomnika.v15i1.7187

Simple Method for Non Contact Thickness Gauge using Ultrasonic Sensor and Android Smartphone

Anif Jamaluddin*, Fita Listiana, Dwi Teguh Rahardjo, Lita Rahmasari, Dewanto Harjunowibowo
Physics Education Program, Sebelas Maret University, Indonesia
Jl. Ir. Sutami 36 A, Surakarta, Indonesia
*Corresponding author, e-mail: elhanif@uns.ac.id

Abstract

The aim of this research is to develop simple method for non contact thickness gauge using ultrasonic sensor and android smartphone. This system is constructed using ultrasonic sensor HY-SRF05, microcontroller ATMEGA328, bluetooth module and android smartphone. Ultrasonic sensor transmits ultrasonic pulses in the form of waves and recieves back the pulses after the waves are reflected by an object. The time duration of ultrasonic between transmition and reception is calculated as distance between sensor and sample. The method of for thickness measurement adhere sample on holder infront of ultrasonic sensor. The Thickness measurement of sample is calculated base on distance beetwen sensor to holder (fixed barrier) and sample to sensor. The zero position of measurement is distance of sensor to holder. The data of thickness is sent via bluetooth and received by the Android application. Android Application uses to display measurement is designed base on MIT App Inventor for Android (AIA) platform. The measurement results show a fairly high degree of accuracy is 99.978%.

Keywords*: ATMega328, ultrasonic sensor HY-SRF05, bluetooth module, Android, App Inventor*

1. Introduction

The aim of this research is to develop non contact thickness gauge using simple method. It can applicated on on mobile data acquisition using android smartphones. The research is development from common analog into digital thickness gauge (calliper, micrometer).

In an analog thickness gauge (calliper, micrometer), the measurement results should consider reading errors (parallax) which can be one of the causes of the inaccuracies in the measurement results. The difficulty in using analog thickness measurement can be solved by developing a digital measurement. But, the digital thickness instrument still has a weakness, when it used to measure elastis objects that the shape are easy to change when pressed.

The non contact thickness gauge method is proposed to solve the problem. On the research proposes design using ultrasonic sensor. The ultrasonic sensor is one of the most accurate sensor for non contact distance measurement [1]. The novelty of our research is modifying distance measurement to thickness gauge. In addition, the result of gauge can be displayed on mobile phone.

The Ultrasonic sensor transmits ultrasonic pulses in the form of waves and recieves back the pulses after the waves reflected by object. Microcontroller ATmega328 with arduino platform is chosen because it is easy to use so that the emphasis on efficiency and cost effectiveness [2]. The Wireless communication for transmission data from microcontroller uses bluetooth communication. It is chosen because it is simpler than GSM communication and require less power than Wi-Fi. Bluetooth has wireless technology with a short-range operating at 2.4 GHz, and relatively cheaper [2, 3]. The first step for design of non contact thickness gauge method is setting zero position as distance between ultrasonic sensor and holder. When the object was adhered on holder infront of ultrasonic sensor, microcontroller calculated distance between sensor and sample. The thickness of object is distance between sensor-holder (zero position) minus distance between sensor-sample.

The android smartphone devices presented as a real time data acquisition for blood presure monitoring [4], electrocardiogram in medicine [5] and RFID reader [6]. The thickness

Received November 2, 2014; Revised January 26 2015; Accepted February 15, 2015

gauge results are displayed on Android Smartphone using android application. Android Application is developed using MIT App Inventor for Android (AIA) platform. It relatively easy for someone with no programming skills and have made no special software [7]. The purpose of this research is to design of non contact thickness of elastic object. It is applied for mobile measurement using android smartphone for displaying data acquisition.

2. Research Method

The Design of non contact thickness gauge consists of some hardware (such as ultrasonic sensor HY-SRF05, microcontroller ATmega328, bluetooth module, android smartphone) and software (such as Arduino IDE and App Inventor). Figure 1 shows the experiment schematic of wireless thickness gauge device based on Android and a microcontroller.

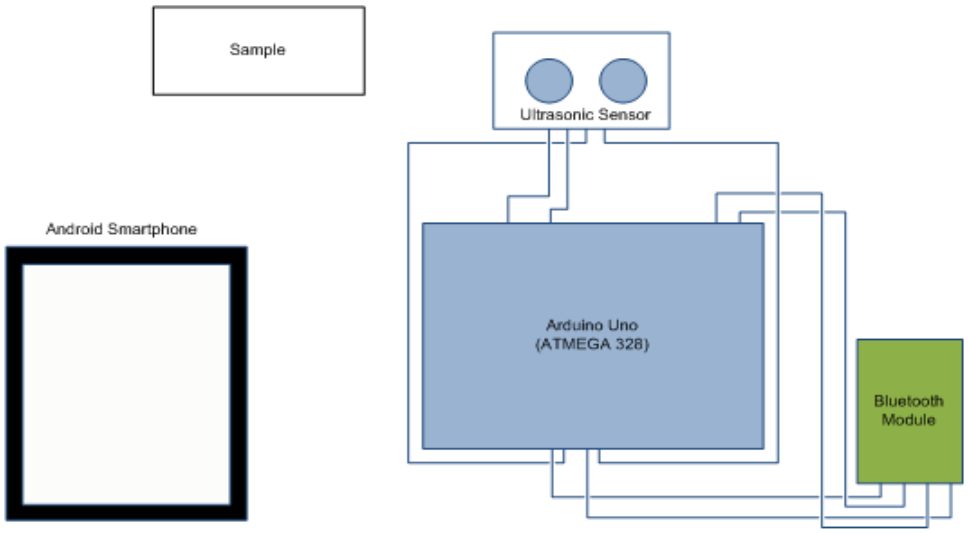
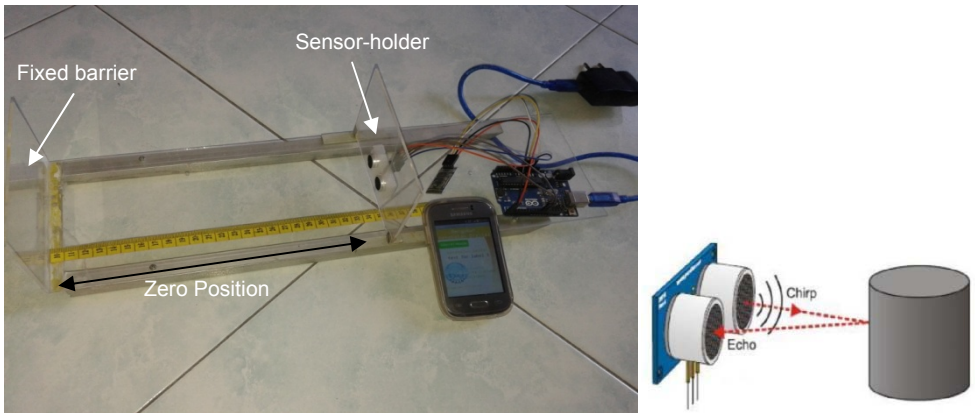


Figure 1. Schematic circuit of wireless thickness gauge

Working Principle. The first step, we have to calculate zero position as distance measurement between ultrasonic sensor and holder (fixed barrier). On the zero position, actual distance (sensor-holder) is converted as zero (0) on measurement. Figure 2.a shows the experiment for zero position setting.



a b

Figuire 2 Calculation zero position; a. Schematic of zero position setting, b. Ultrasonic distance principle

The Ultrasonic sensor detects object by sending ultrasonic sound and then "listen" echoes. Figure 2. B shows ultrasonic distance principle. The velocity of ultrasonic on the air is 344.42 m/s or 0.3444 m/μs. The time duration (Δt) between transmission and recieving of ultrasonic is calculated as distance (s) between sensor and sample with following equation 1.

$$s = \frac{v \cdot \Delta t}{2}$$
$$s = \frac{0.03444 \cdot \Delta t}{2}$$
$$s = \frac{\Delta t}{2 * 29} \quad (1)$$

Hardware Implementation. Ultrasonic sensor type HY-SRF05 work on DC voltage 5 V, has a sensor angle less than 15 degrees, and it can measured accurately at a distance of 2 cm to 450 cm [1]. The sensors transmit ultrasonic sound waves with a frequency between 25 kHz and 50 kHz [8]. Microcontroller arduino uno is a a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started [2]. On this paper, we used bluetooth module HC-06. It can connect 3.3 to 5VDC power supply and connect TX and RX for controling.

This research used arduino integreted development environtment program (IDE) which embededed on ATMEGA 328 (Arduino). App Inventor for android is used for android application development, that displays data acquisition of thickness on android smartphone.

Embeded Program. The Arduino integrated development environment (IDE) is a cross-platform application written in Java, is derived from the IDE for the Processing programming language and the Wiring projects. Arduino programs are written in C or C++ language [2]. Figure 3 a. shows the flowchart of embededded program.

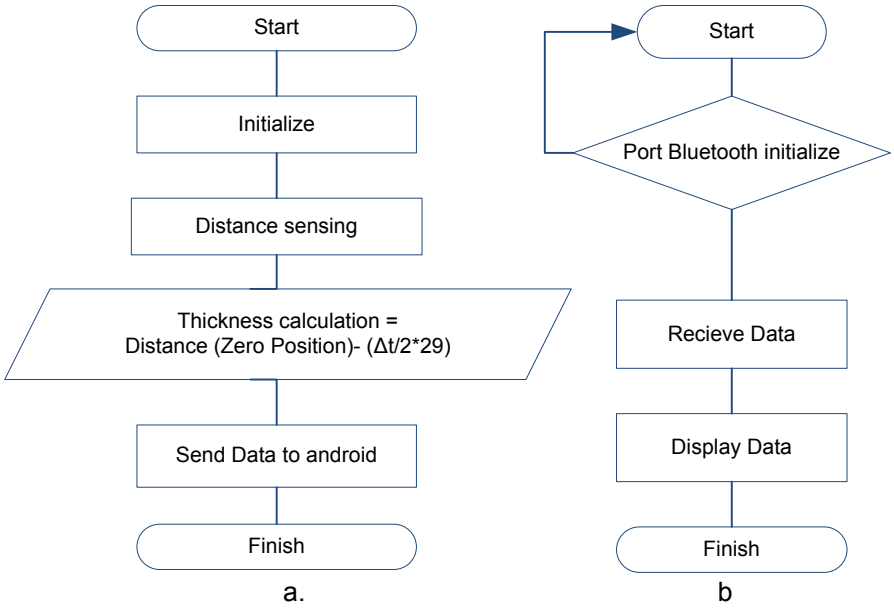
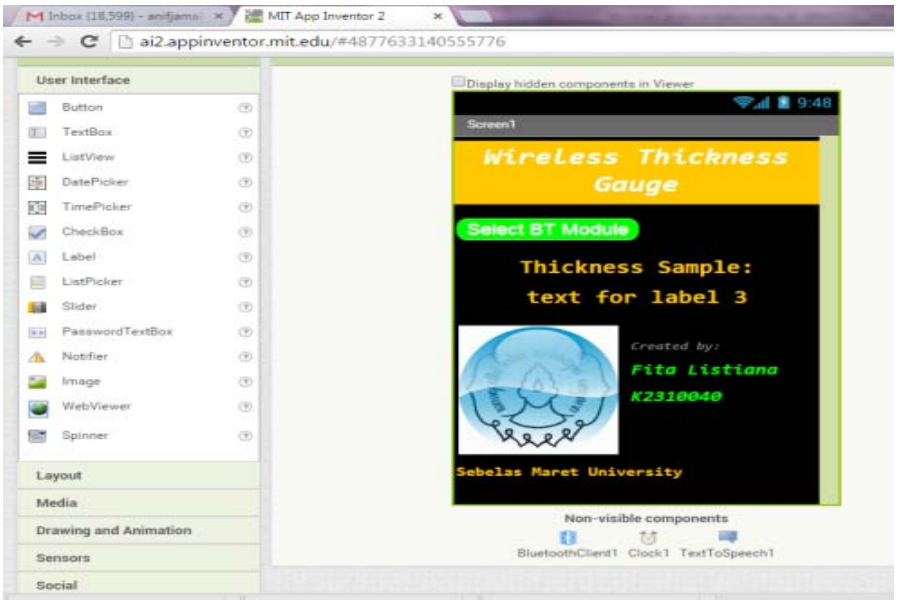


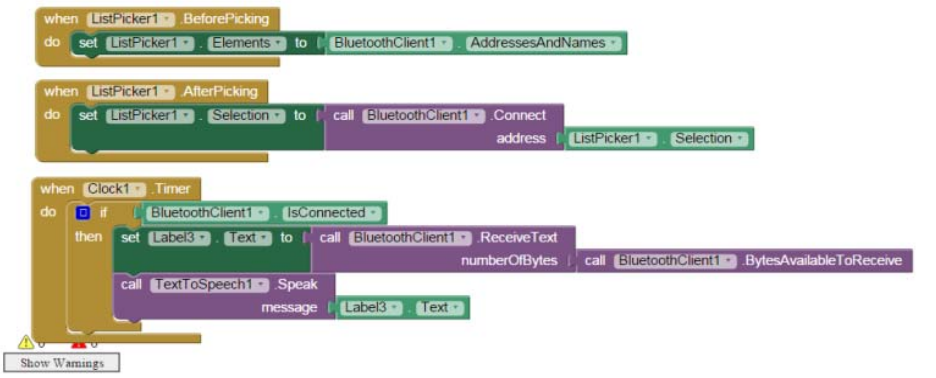
Figure 3. Arduino programming; a. Flowchart embeded program, b. Flowchart to display thickness gauge on android smartphone

Android Application. App Inventor for Android (AIA is Developed by MIT Media Lab for education purposes. App Inventor is a Scratch-based visual programming language. Furthermore, App Inventor is a web interface development environment. The programming is made in a visual rather than a conventional way. The program can be uploaded to a smart phone directly [6]. Figure 3.b shows a flowchart of displaying thickness gauge on android smartphone.

The design of android application with App inventor consisted of two parts (component diagram and block diagram). The component diagram was used for design layout to display on android smartphone. A block diagram was used for design programming of android. AIA has library for communication with accelerometer sensor, GPS, WiFi and Bluetooth [6]. On this system, the library of bluetooth is used for data communication. Figure 4 a. and 4.b show App Inventor component and block diagram.



a



b

Figure 4. The library of bluetooth; a. App inventor layout display b. app Inventor block diagram

3. Result and Discussion

3.1 Thickness Calculation

The first step for calculation of thickness is zero position set up. Zero position is defined as position between ultrasonic sensor and holder (Fixed barrier). In this research, the distance between sensor and holder is 19.80 cm but on the display instrument shows 0.00 cm. Figure 5.a

shows the experimental set up for calculation thickness of sample. The thickness calculation of sample is following equation (2)

Thickness = s (zero position) – s (sensor to object)

$$\text{Thickness} = s \text{ (zero position)} - \frac{\Delta t}{2*29} \quad (2)$$

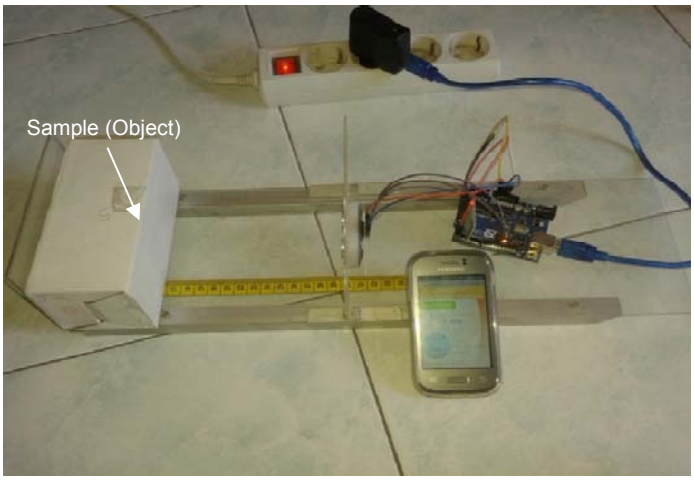


Figure 5. Experiment of Wireless Thickness Gauge

When there are object (sample) in front of sensor, Ultrasonic sensor transmits the waves to object which is reflected by the object to the detector. Microcontroller calculated thickness of object as following equation (2). The thickness data is transmitted by bluetooth communication into android smartphone. The system is designed for non contact measurement and wireless communication.

3.2 Experimental Result

The non-contact thickness gauge was developed using ultrasonic sensor. An android smartphone displayed data acquisition of thickness object by bluetooth communication. Fig 6shows screen shoot of android application for thickness gauge. The bluetooth select button is designed to make a connection between bluetooth and microcontroller. Over bluetooth connected, the thickness data displayed on android smartphone with real time.

The wireless thickness gauge has been tested to measure thickness sample. The result shows a slightly different with actual measurement using standard micrometer. Figure 7 shows the comparison of measurement between this method and actual measurement.

Based on Figure 7, the fitting linear regression tool was used for analysis an accuracy of measurement. The accuracy of measurement is 99.978%. This method used non-contact between object and sensor. It was compatible to measure thickness on elastic or plastic object. This method was simple and applicable to use as mobile data acquisition using android smartphone. Other researcher used ultrasonic sensor for inspecting wall thickness measurement [9] and pipe wall [10]. It used contact method (contact between sample with sensor) for thickness detection. The novelty of our research is non-contact thickness measurement and mobile data acquisition.

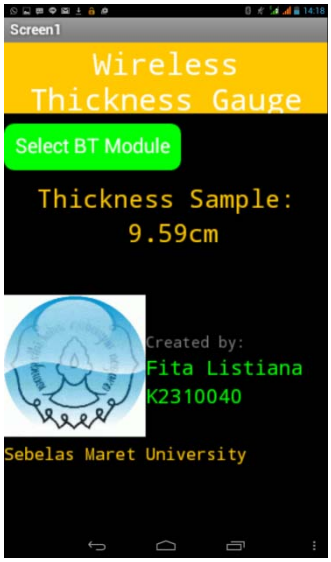


Figure 6. Screen shoot android application for thickness gauge

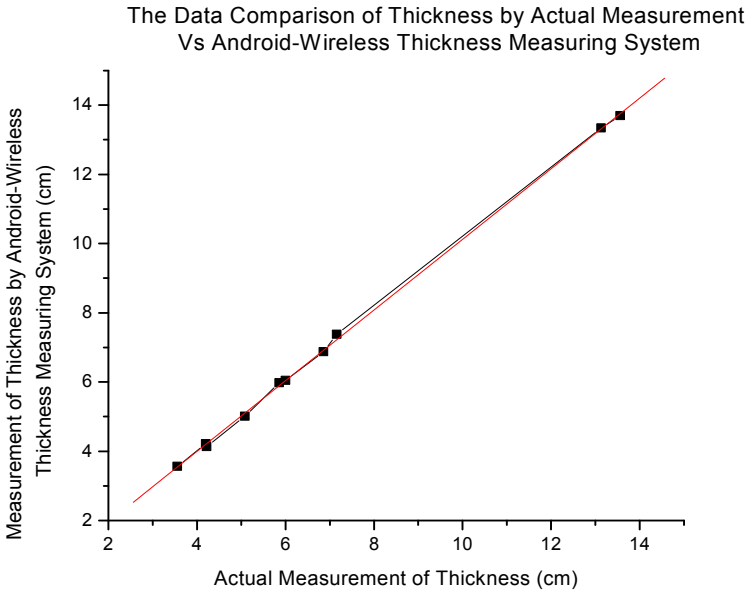


Figure 7 The comparasion of hhickness measurement by android vs micrometer

4. Conclusion

A non contact and wireless thickness gauge system has been successfully created with the ATmega328 microcontroller, HY-SRF05 ultrasonic sensor, a Bluetooth module, and Displaying on android smartphone. It is a wireless and non-contact measurement. The results of thickness gauge with a wireless measuring based on Android and microcontroller have an accuracy rate of 0.99978 or 99.978%.

Acknowledgement

This work was partially supported by Sebelas Maret University's PNBP 2015 Grant.

References

[1] Meier R. *General-Purpose Wireless Distance Sensor*. Master Thesis. Zurich : ETH Zurich. 2014
[2] Jamaluddin A, Perdana F.A, Supriyanto A, Purwanto A, Inayati, Nizam M. *Development of Wireless Battery Monitoring for electric vehicle*. Electrical Engineering and Computer Science (ICEECS), 2014 International Conference on Electric Vehicle. Bali. 2014 : 147-151
[3] Peng Y, et al. *Cognitive FH Channel Selection for Bluetooth Network*. *TELKOMNIKA Indonesian Journal of Electrical Engineering.* 2013; 11(3): 1626-1631
[4] Shivaraman I, Pooja S. *A Non-Invasive Blood Pressure Measurement using Android Smartphone*. IOSR-JDMS, 2014; 13 (1)*:* 28-31
[5] Jithin K, Niranjan D, Biju B. A Real time Data Acquisition and Monitoring Device for Medical Applications based on Android Platform. *International Journal of Advanced Computer Research*. 2013; 3(3):47-51
[6] Lian L. Research on How to Design an Android-based RFID Reader*. TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2014; 12 (9): 6431-6436
[7] Kim H K, Model J. Mobile Application Design Tool for Smartphones: A Tutorial*. International Journal of Soft Computing Engineering (IJSCE)*. 2012; 2: 237-243
[8] Kianpisheh A. Smart Parking System (SPS) Architecture Using Ultrasonic Detector. *International Journal of Software Engineering and Its Applications*. 2012; 6 (3): 51-58
[9] Browmick S. Ultrasonic Inspection for Wall Thickness Measurement at Thermal Power Stations. *International Journal of Engineering Research and Technology*. 2011; 4(1) : 89-107
[10] Nakamoto H, Kojima F, Kato S. Reliability Assessment for Thickness Inspection of Pipe Wall using Probability of Detection. *E-Journal of Advanced Maintenance*. 2014; 5 : 228-237